Engineering Bulletin

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Semiconductor Product Sector

THE SIDAC, A NEW HIGH VOLTAGE TRIGGER THAT REDUCES CIRCUIT COMPLEXITY AND COST

The SIDAC is a high voltage bilateral trigger device that extends the trigger capabilities to significantly higher voltages and currents than have been previously obtainable, thus permitting new, cost-effective applications. Being a bilateral device, it will switch from a blocking state to a conducting state when the applied voltage of either polarity exceeds the breakover voltage. As in other trigger devices, (DIAC, SBS, Four Layer Diode), the SIDAC switches through a negative resistance region to the low voltage on-state (Figure 1) and will remain on until the main terminal current is interrupted or drops below the holding current.

For the MK1V series, the repetitive breakover voltage $V_{(BO)}$ varies from 104 V to 135 V as shown in Table 1. Also listed are the current ratings of the device: the 1.0 A rms current and 20 A surge ratings are perhaps a magnitude greater than the small-signal trigger devices, suggesting much higher energy applications. Although not described, other SIDACs including 240 V devices have similar characteristics and applications.

The basic SIDAC circuit and waveforms, operating off of ac are shown in Figure 2. Note that once the input voltage exceeds $V_{(BO)}$, the device will switch on to the forward on-voltage V_{TM} of typically 1.1 V (Table 2) and can conduct as much as the specified repetitive peak on-state current I_{TRM} of 20 A (10 μs pulse, 1.0 kHz repetition frequency).

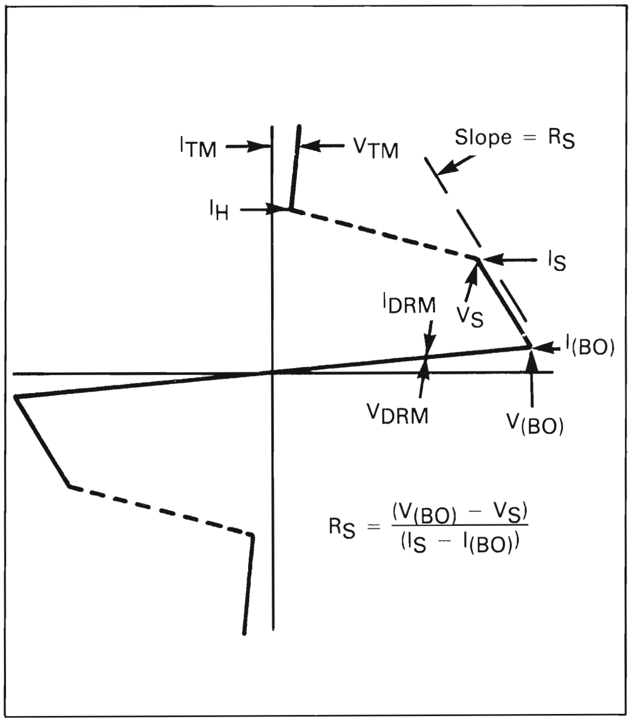

FIGURE 1 — SIDAC V-1 Characteristics

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FIGURE 2 — Basic SIDAC Circuit and Waveforms

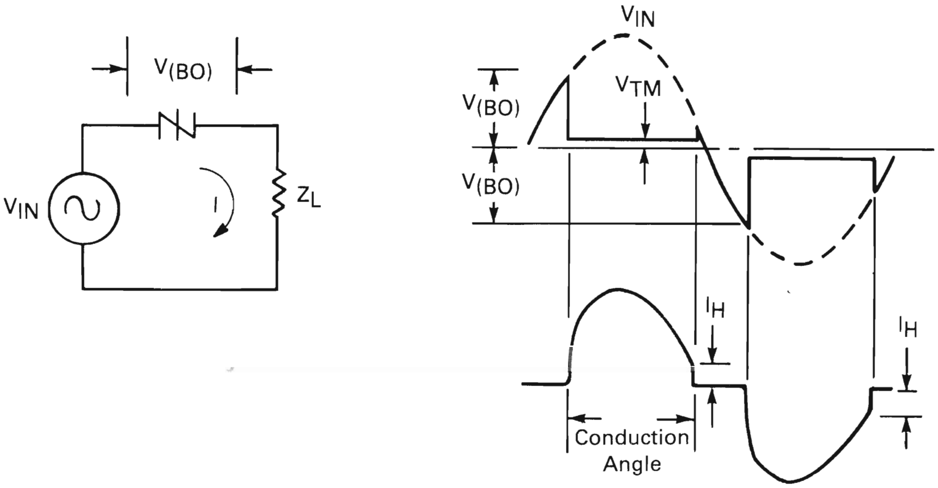


TABLE 1
MAXIMUM RATINGS

Rating	Symbol	Min	Max	Unit
Repetitive Breakover Voltage	$V_{(BO)}$			Volts
MK1V-115		104	115	
MK1V-125		110	125	
MK1V-135		120	135	
Off-State Repetitive Voltage	V_{DRM}	—	±90	Volts
On-State Current RMS (All Conduction Angles)	$I_{T(RMS)}$	—	1.0	Amps
On-State Surge Current (Nonrepetitive) (60 Hz One Cycle Sine Wave, Peak Value)	I_{TSM}	—	20	Amps
Operating Junction Temperature Range	T_J	-40	+125	°C
Storage Temperature Range	T_{stg}	-40	+150	°C
Lead Solder Temperature (Lead Length ⩾ 1/16″ from case, 10 s Max)	—	—	+230	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	—	15	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	—	45	°C/W

TABLE 2
ELECTRICAL CHARACTERISTICS (T_J = 25°C unless otherwise noted; both directions.)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakover Current (60 Hz Sine Wave)	$I_{(BO)}$	—	—	200	μA
Repetitive Peak Off-State Current (60 Hz Sine Wave, V = V_{DRM})	I_{DRM}	—	—	10	μA
Repetitive Peak On-State Current (T_C = 25°C, Pulse Width = 10 μs, Repetition Frequency, f = 1.0 kHz)	I_{TRM}	—	20	—	Amps
Forward "On" Voltage (I_{TM} = 1.0 A peak)	V_{TM}	—	1.1	1.5	Volts
Dynamic Holding Current (60 Hz Sine Wave)	I_H	—	—	100	mA
Switching Resistance	R_S	0.1	—	—	kΩ
Maximum Rate of Change of On-State Current	di/dt	—	50	—	A/μs

The other important device characteristics — holding current, breakover current, forward voltage, power dissipation and temperature ratings — are illustrated in the curves of Figures 3 through 8 respectively.

This data, plus the thermal resistance, junction to ambient $R_{\theta JA}$ of 45°C/W show that this axial lead, plastic encased package will dissipate about 2.0 watts ($P_D = \Delta T/R_{\theta JA}$ = (125°C)/45°C/W = 2.2 W).

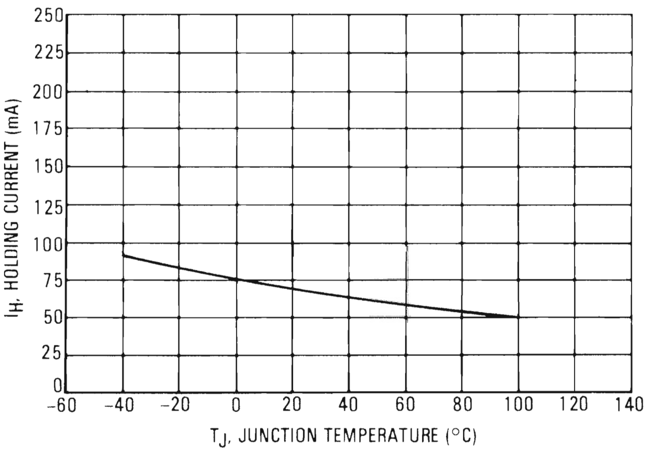


FIGURE 3 — Typical Holding Current

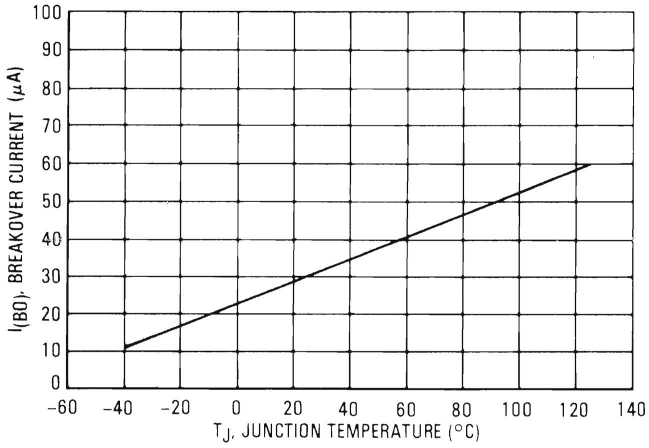


FIGURE 4 — Typical Breakover Current

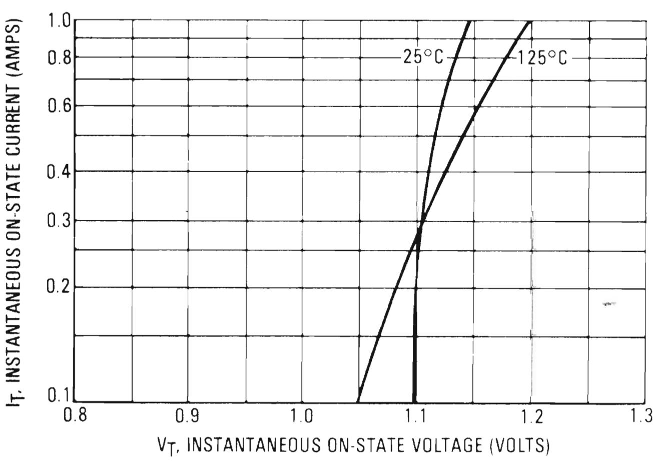


FIGURE 5 — Typical Forward Voltage

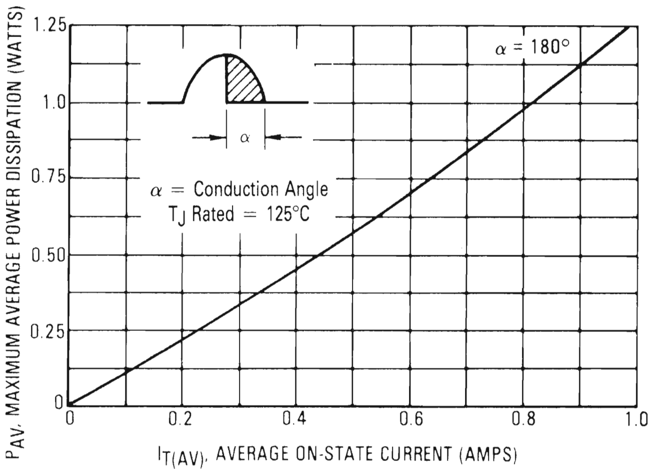


FIGURE 6 — Power Dissipation

CURRENT DERATING

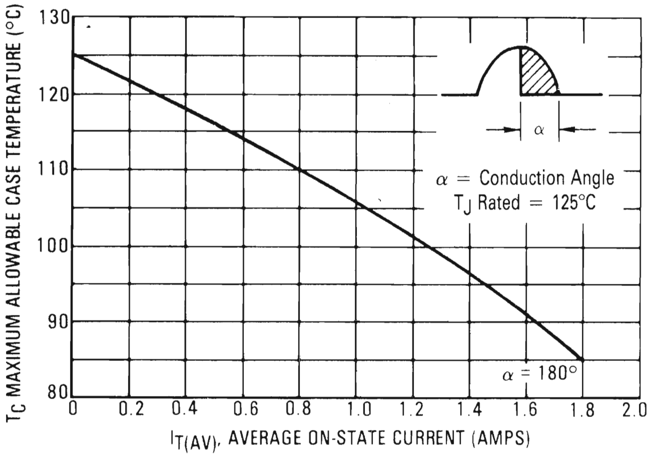


FIGURE 7 — Maximum Case Temperature

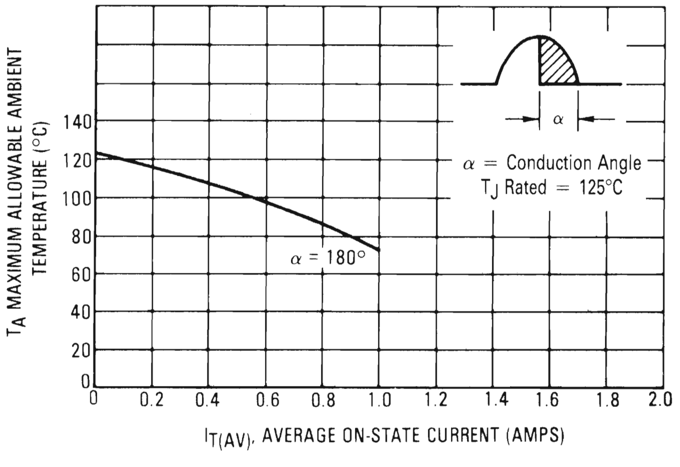


FIGURE 8 — Maximum Ambient Temperature

How can the SIDAC be used? One application is to replace the combination of a small-signal trigger and TRIAC with the SIDAC, as shown in Figure 9. In this example, the trigger — an SBS (Silicon Bidirectional Switch) that conducts at about 8.0 V — will fire the TRIAC by dumping the charge from the capacitor into the gate of the TRIAC. This circuit is amenable to phase controlling the TRIAC, if so required, as the RC time constant can be readily varied.

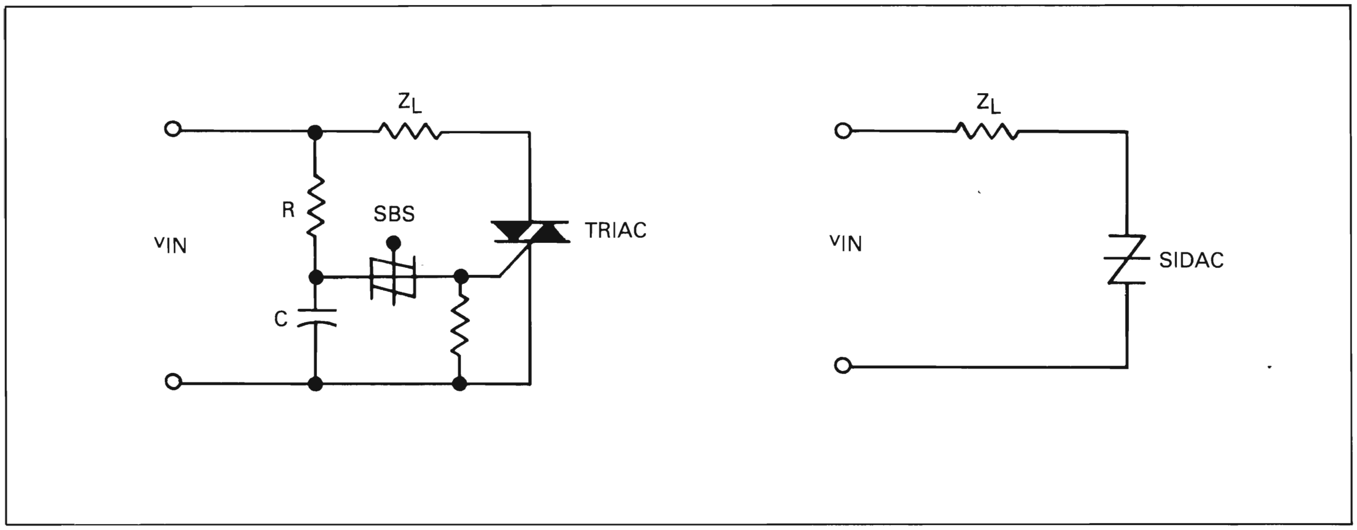


FIGURE 9 — Comparison of a TRIAC and SIDAC Circuits

The simple SIDAC circuit can also supply switchable load current. However, the conduction angle is not readily controllable, being a function of the peak applied voltage and the breakover voltage of the SIDAC. As an example, for peak line voltage of about 170 V, at $V_{(BO)}$ of 115 V and a holding current of 100 mA, the conduction angle would be about 130°. With higher peak input voltages (or lower breakdown voltages) the conduction angle would correspondingly increase. For non-critical conduction angle, 1.0 A rms switching applications, the SIDAC is a very cost-effective device.

Since the MK1V series of SIDACs have relatively tight $V_{(BO)}$ tolerances (104 V to 115 V for the −115 device), other possible applications are over-voltage protection (OVP) and detection circuits. An example of this, as illustrated in Figure 10, is the SIDAC as a transient protector in the transformer-secondary of the medium voltage power supply, replacing the two more expensive back-to-back zeners or an MOV. The device can also be used across the output of the regulator (< 100 V) as a simple OVP but for this application, the regulator must have current foldback or a circuit breaker (or fuse) to minimize the dissipation of the SIDAC.

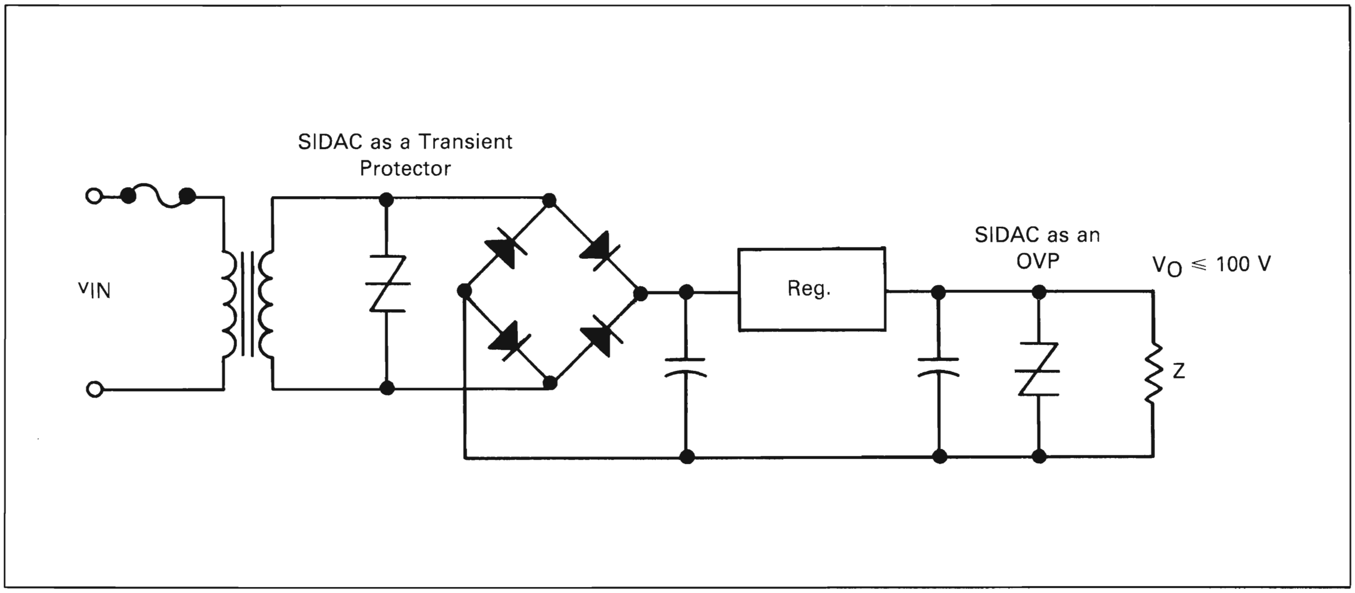


FIGURE 10 — Typical Applications of SIDACS as a Transient Protector and OVP in a Regulated Power Supply

Another example of OVP is in telephony applications as illustrated in Figure 11. To protect the Subscriber Loop Interface Circuit (SLIC) and its associated electronics from voltage surges, two SIDACs and two rectifiers are used for secondary protection (primary protection to 1,000 V is provided by the gas discharge tube across the lines). As an example, if a high positive voltage transient appeared on the lines, rectifier D1 (with a P.I.V. of 1,000 V) would block it and SIDAC D4 would conduct the surge to ground. Conversely, rectifier D2 and SIDAC D3 would protect the SLIC for negative transients. The SIDACs will not conduct when normal signals are present.

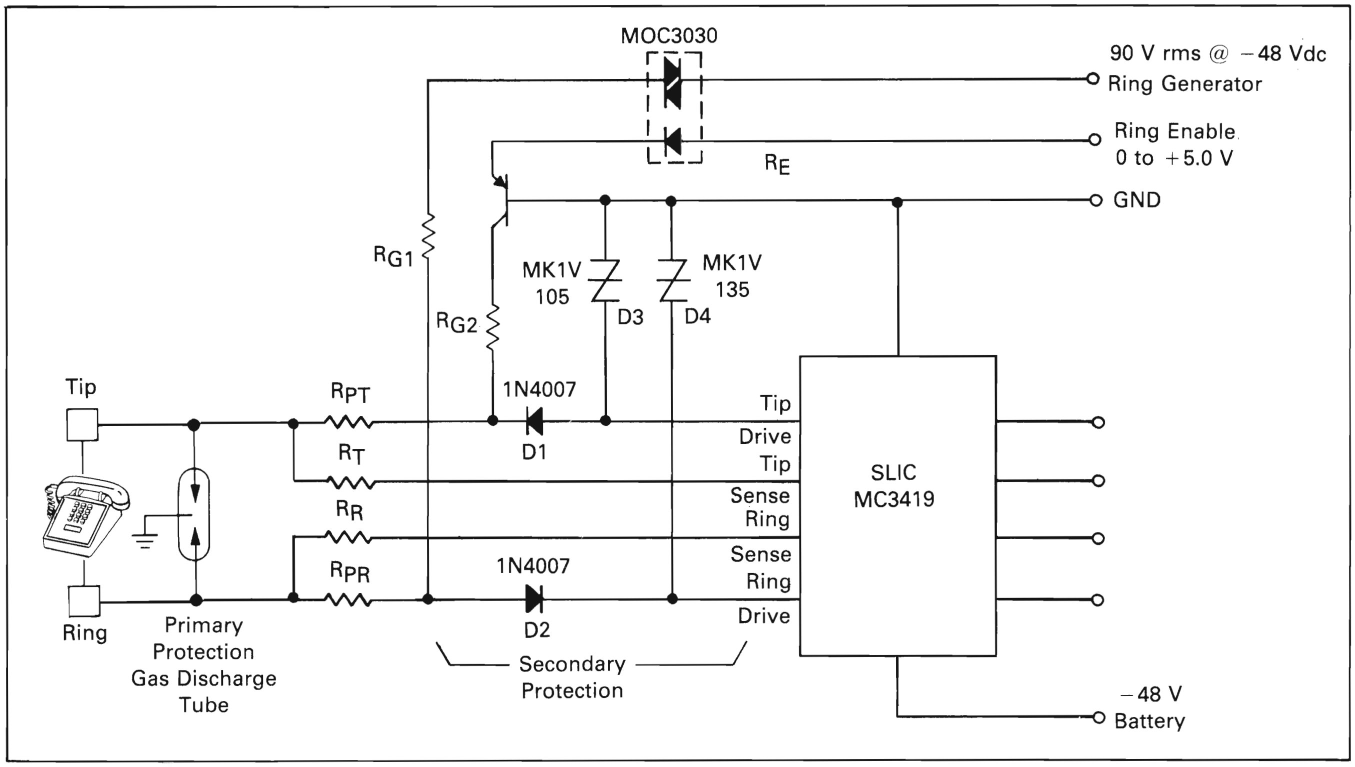
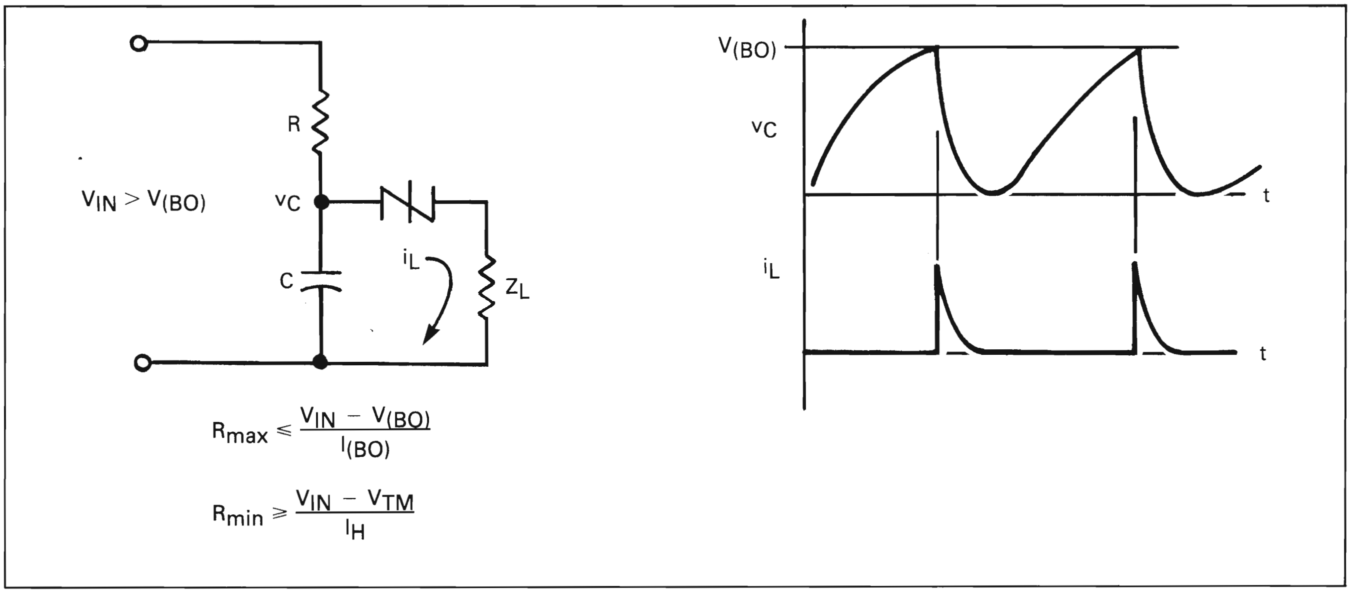


FIGURE 11 — SIDACs Used for OVP in Telephony Applications

Being a negative resistance device, the SIDAC also can be used in a simple relaxation oscillator where the frequency is determined primarily by the RC time constant (Figure 12). Once the capacitor voltage reaches the SIDAC breakover voltage, the device will fire, dumping the charged capacitor. By placing the load in the discharge path, power control can be obtained; a typical load could be a transformer-coupled xeon flasher, as shown in Figure 13A.



$$R_{max} \leq \frac{V_{IN} - V_{(BO)}}{I_{(BO)}}$$

$$R_{min} \geq \frac{V_{IN} - V_{TM}}{I_H}$$

FIGURE 12 — Relaxation Oscillator Using a SIDAC

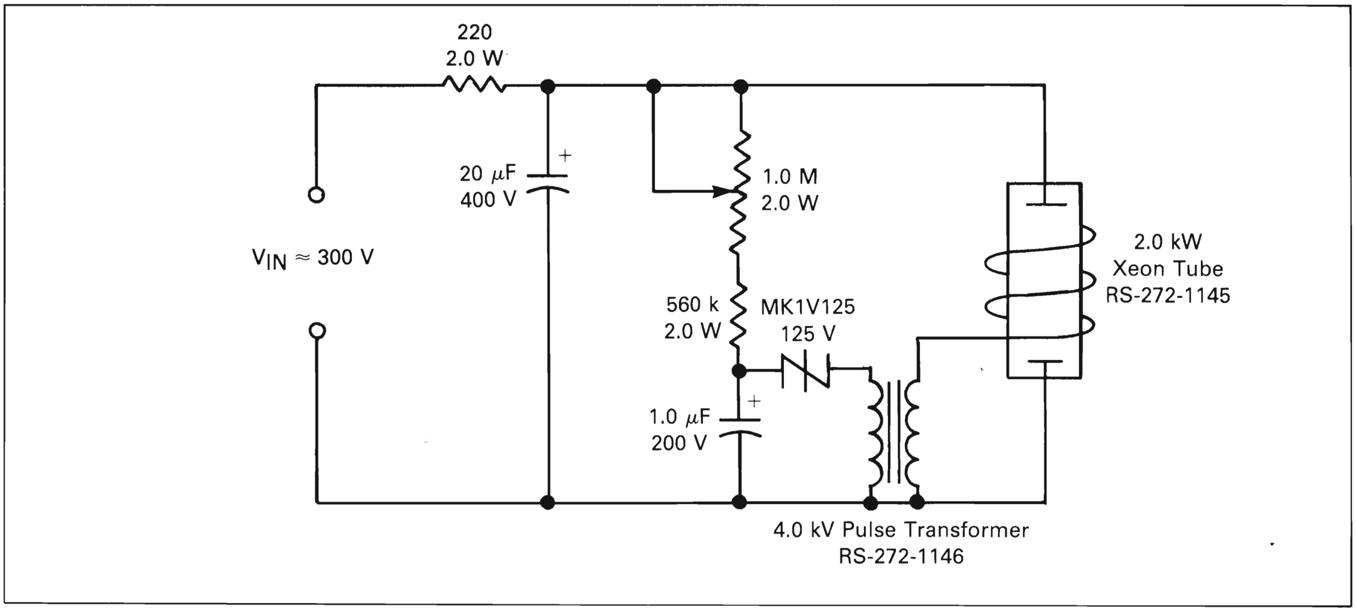


FIGURE 13A — Xeon Flasher Using a SIDAC

Other high voltage, nominal current trigger applications are:

- HV lamp igniters
- Gas or oil igniters
- HV electrostatic air filters
- Fluorescent lamp and other gas discharge tube starters
- CD ignition

Note that all of these applications use similar circuits, the dumping of a charged capacitor to generate a high transformer secondary voltage, (Figure 13b). Also, the OVP discharges a charged output filter capacitor and the surge suppressor must sustain an electrical transient, typically exponential in shape. The question then becomes; how much "real world" surge current can the SIDAC sustain? The data sheet defines an I_{TSM} of 20 A, but this is for a 60 Hz, one cycle, peak sine wave whereas the capacitor discharge current waveform has a fast-rise time with an exponential fall time.

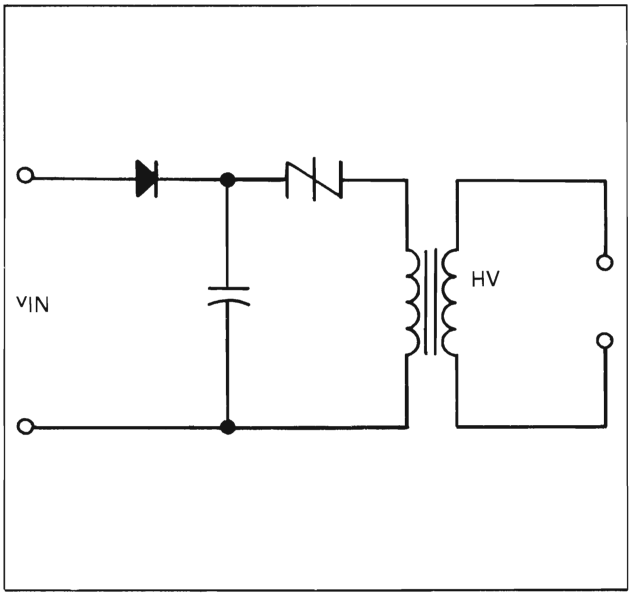


FIGURE 13B, — Typical Capacitor Discharge Sidac Circuit

To generate the surge current curve of peak current versus exponential discharge pulse width, the test circuit of Figure 14 was implemented. It simulates the topology of many applications whereby a charged capacitor is dumped by means of a turned-on SIDAC to produce a current pulse. Timing for this circuit is derived from the nonsymmetrical CMOS astable multivibrator (M.V.) gates G1 and G2. With the component values shown, an approximate 20 second positive-going output pulse is fed to the base of the NPN small-signal high voltage transistor Q1, turning it on. The following high voltage PNP transistor is consequently turned on, allowing capacitor C1 to be charged through limiting resistor R1 in about 16 seconds. The astable M.V. then changes state for about 1.5 seconds with the positive going pulse from Gate 1 fed through integrator R2-C2 to Gate 3 and then Gate 4. The net result of about a 100 μs time delay from G4 is to ensure non-coincident timing conditions. This positive going output is then differentiated by C3-R3 to produce an approximate 1.0 ms, leading edge, positive going pulse which turns on NPN transistor Q3 and the following PNP transistor Q4. Thus, an approximate 15 mA, 1.0 ms pulse is generated for turning on SCR Q5 about 100 μs after capacitor charging transistor Q2 is turned off. The SCR now fires, discharging C1 through the current limiting resistor R4 and the SIDAC Device Under Test (D.U.T.). The peak current and its duration is set by the voltage V_C across capacitor C1 and current limiting resistor R4. The circuit has about a 240 V capability limited by C1, Q1 and Q2 (250 V, 300 V and 300 V respectively).

The SCR is required to fire the SIDAC, rather than the breakover voltage, so that the energy to the D.U.T. can be predictably controlled.

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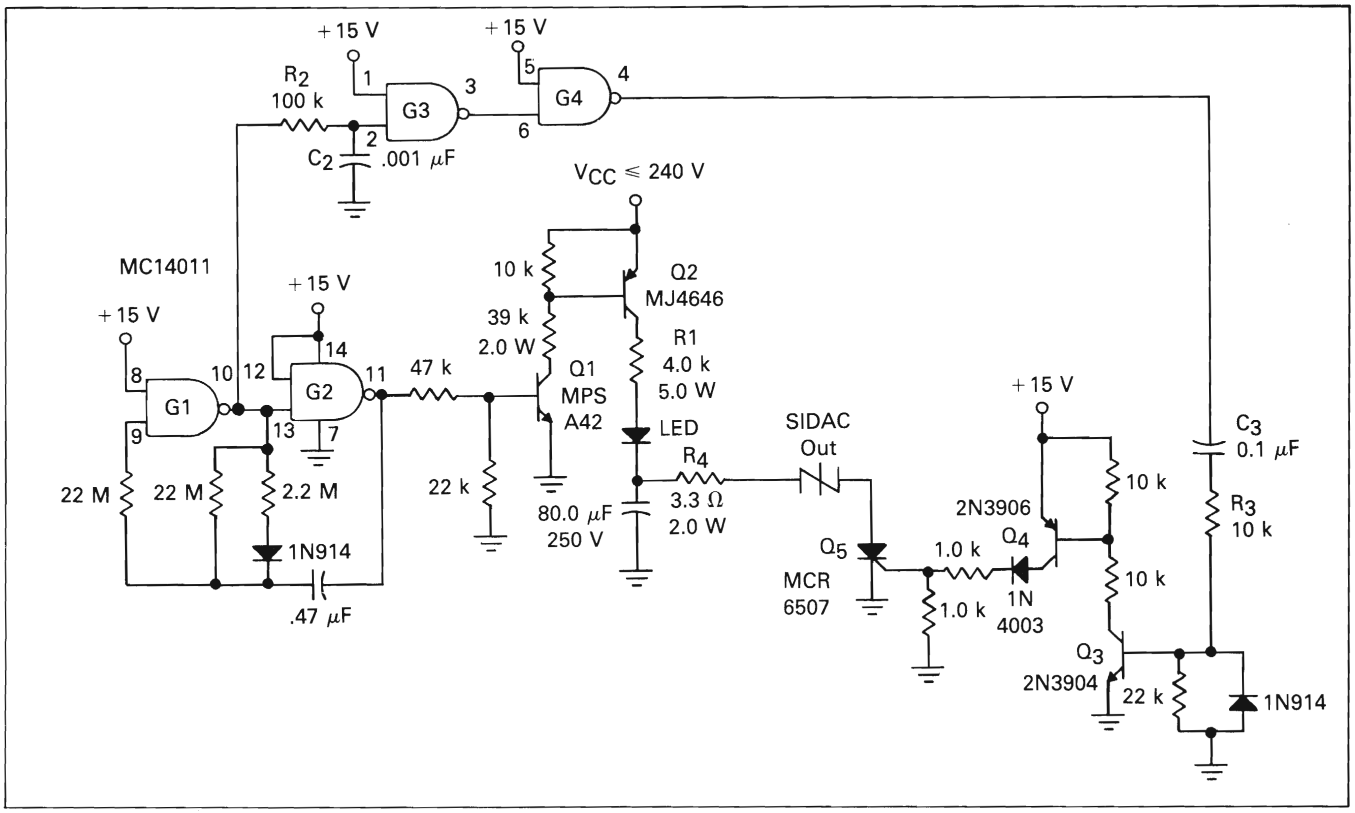

FIGURE 14 — SIDAC Surge Tester

By varying V_C, C1 and R4, the surge current curve of Figure 15 was derived. Extensive life testing and adequate derating ensure that the SIDAC, when properly used, will reliably operate in the various applications.

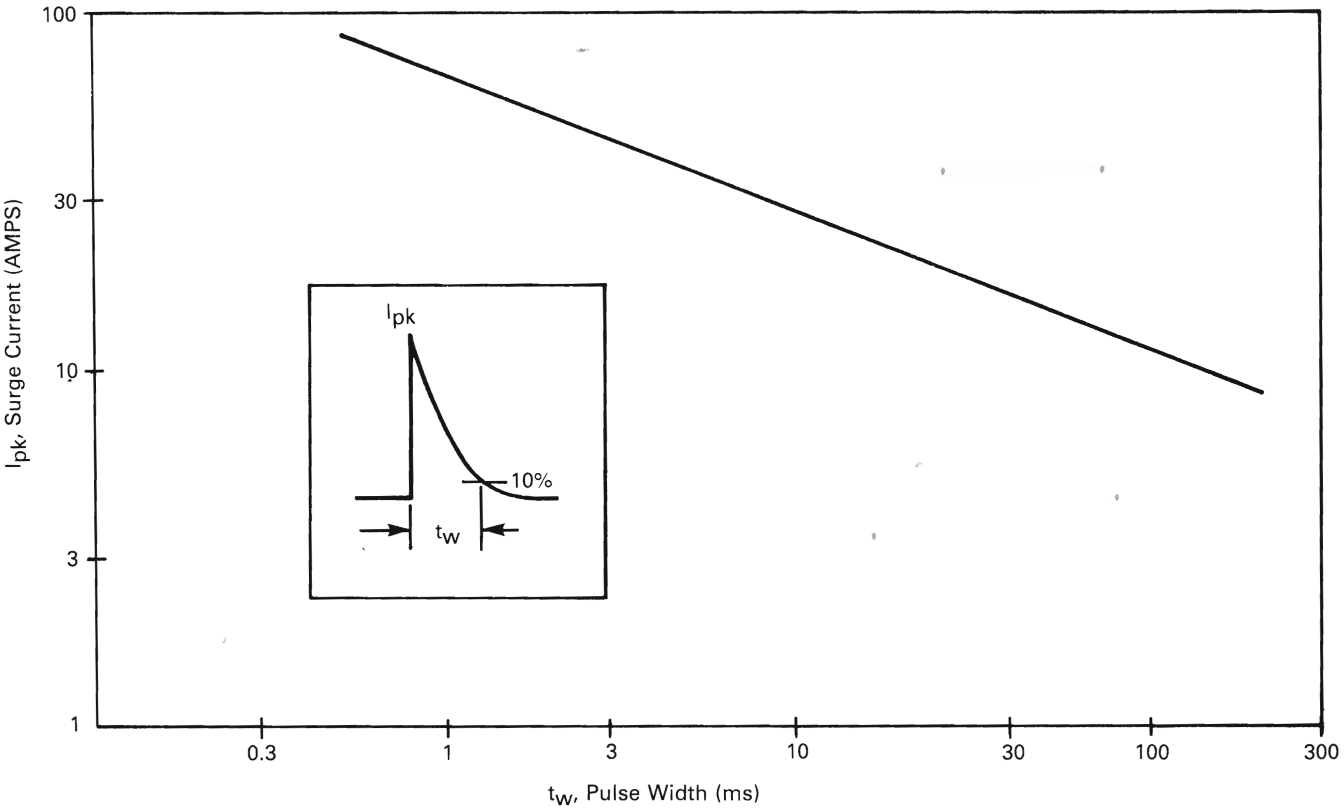

FIGURE 15 — Exponential Surge Current Capability of the MK1V SIDAC. Pulse Width vs Peak Current

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